ABOVE AND UNDERWATER PILE INSPECTION REPORT

MAGNOLIA PIER
MAGNOLIA HARBOR, GLOUCESTER, MA

PREPARED FOR:
City of Gloucester Waterway's Board and Harbormaster's Office
19 Harbor Loop
Gloucester, Massachusetts

PREPARED BY:
GZA GeoEnvironmental, Inc.
372 Merrimac Street
Newburyport, Massachusetts

September 2015

File No. 18.0172459.00

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A. GENERAL

1. INTRODUCTION

On August 21, 2015 engineers from GZA GeoEnvironmental, Inc. (GZA) performed a one-day above-water and underwater inspection of the existing timber support piles at the Magnolia Pier in Gloucester, Massachusetts in accordance with the purchase order dated August 18, 2015.

The inspection was limited to the accessible above-water and underwater portions of the timber piles supporting the pier. The purpose of the inspection was to observe and document the existing condition, layout, spacing, and dimensions of the timber pier and piles, identify the limits of damage on the piles, and assess the overall general condition to establish baseline conditions for future inspections. No utilities/building structures, floats, gangways or any other ancillary structures associated with the pier were included in the inspection scope of work, although general observations of the pier structure were noted.

The structures observed were assessed a condition rating based on the following Condition Rating Assessment table:

Condition Rating Assessment - Table 1	
Rating	**Description**
6 - Good	No visible damage, or only minor damage is noted. Structural elements may show very minor deterioration, but no overstressing is observed. No repairs are required.
5 - Satisfactory	Limit minor to moderate defects or deterioration are observed, but no overstressing is observed. No repairs are required.
4 - Fair	All primary structural elements are sound, but minor to moderate defects or deterioration is observed. Localized areas of moderate to advanced deterioration may be present but do not significantly reduce the load-bearing capacity of the structure. Repairs are recommended, but the priority of the recommended repair is low
3 - Poor	Advanced deterioration or overstressing is observed on widespread portions of the structure but does not significantly reduce the load-bearing capacity of the structure. Repairs may need to be carried out with moderate urgency.
2 - Serious	Advanced deterioration, overstressing, or breakage may have significantly affected the load-bearing capacity of primary structural components. Local failures are possible and loading restrictions may be necessary. Repairs may need to be carried out on a high-priority basis with urgency.

Condition Rating Assessment - Table 1	
Rating	**Description**
1 – Critical	Very advanced deterioration, overstressing, or breakage has resulted in localized failure(s) of primary structural components. More widespread failures are possible or likely to occur, and load restrictions should be implemented as necessary. Repairs may need to be carried out on a very high priority basis with strong urgency.

Table 2-4. From Routine Underwater Condition Assessment Ratings, Page 21, Underwater Investigations Standard Practice Manual, as published in the ASCE Manuals and Reports on Engineering Practice No.101, Copyright 2001.

2. INSPECTION PROCEDURES

The above-water and underwater inspections included visual and tactile inspections of the accessible portions of the timber piles. The inspection procedures included documentation of existing conditions by field notes, photography, videography. Access to the support piles during the inspection was from the shoreline at low tide, top of the timber pier, floating dock and swimming the structures with observations above and below water performed.

Prior to the pier inspection work, GZA personnel visited the site to observe overall site conditions on August 6, 2015. Several photographs were taken at that time with select photographs of that site visit provided in Appendix B of this report.

The underwater inspections were performed in accordance with OSHA Subpart T – Commercial Diving directives and the American Society of Civil Engineers (ASCE), Underwater Investigations, Standard Practice Manual, No. 101. Underwater dive operations were performed during the day at low tide in approximately 0 to 10 foot water depths with 65-degree water temperature and approximately 10 to 15 foot visibility. Inspection limitations are indicated in Appendix A.

The underwater inspections included a Level I inspection effort that involved visual and tactile inspections of the piles and a limited Level II inspection. Level I inspection is generally referred to as a "swim-by" inspection, performed to the level of detail necessary to detect obvious major damage or deterioration. For this inspection, 100 percent of the piles were included in the Level I inspection. In addition, GZA performed a modified, limited Level II inspection effort to include removal of marine growth or scaling to expose an approximate 12-inch square area at selected areas of the timber piles. Level II inspection was performed on select piles as applicable. Level II inspections are directed towards detecting and identifying deteriorated areas that may be hidden by surface biofouling or deterioration.

a. Documentation

The documentation resulting from the above-water and underwater inspection included field notes, photographs, underwater photographs and underwater video that were taken of the general conditions encountered. Select site inspection photographs taken on August 6, 2015 and August 21, 2015 are presented in Appendix B of this report and are also referenced within the text of the report.

Appendix C of the report provides a drawing describing the conditions encountered. The drawing was created by using an aerial image and tracing the site features in CAD and supplementing with field measurements to create the drawing.

b. Non-Destructive Testing

No non-destructive testing was performed on the existing timber piles. Cleaning associated with the Level II underwater inspection was performed without damage to the pile.

3. SITE CONDITIONS

The site is a City-owned facility that is comprised of a timber pile-supported and timber framed pier with an associated aluminum gangway providing access to a seasonal, bottom-anchored timber float. The pier is also used for access to several dingy outhauls tied up along both the north and south sides of the pier. The site is located within Magnolia Harbor to the southwest of Gloucester Harbor at 54 Shore Road, Gloucester, MA.

The pier is composed of an approximate 6-foot wide by 270-foot long timber pier that has a southwest jog southwest approximately 120 feet from the shoreline. The pier is supported by (52), 12-inch diameter, creosote-treated timber plumb piles spaced at approximately ten feet on center with (16), 12-inch diameter, creosote-treated timber batter piles spaced at roughly every third bent along the pier starting at the 5th bent from shore (approximately 60 feet). Based on visual observation, it appears the top of the pier is approximately 9 to 10 feet above mean high water level.

Although not include in the scope of work, GZA field engineers noted that the pier framing is composed of (2), 3x12 split pile caps per bent, (3) 6x6 timber stringers spaced at 2.5 to 3 feet on center, 3x12 timber cross-bracing at varying bents and 2x8 timber decking. Framing and decking members were generally creosote-treated timber although newer pressure-treated timbers were observed, presumably replacement members as a result of recent repairs. A 3-foot wide by 30-foot long aluminum gangway, located on the north side of the pier provides access to a 20.5-foot long by 10-foot wide timber bottom-anchored float (See

Photographs 9-10 in Appendix B). Timber railing exists on both sides of the pier, with the exception of an approximate 10 lineal foot portion of missing rail near the seaward end along the north side of the pier and at the seaward end of the pier (see Photograph 27). The railing system is composed of 4x4 timber posts spaced at approximately 10 feet on center, a 2x8 mid rail and a 4x4 top rail. Several metal and wood ladders are attached to the pier on each side to provide access to the dingy outhauls. (See Figure 1 in Appendix C for Existing Site Inspection Plan and Photographs 1-6 in Appendix B).

B. EXISTING CONDITIONS

1. GENERAL

The observations below are based on above-water and underwater inspection of the support piles at the Magnolia Pier. A plan of the structure is included in Appendix C of this report.

The drawing in Appendix C designates the existing pier piles according to their respective row and bent number. Rows are labeled A through D on the seaward end of the structure and represent the batter pile and plumb pile rows. Row A is the northern most batter pile, B is the northern plumb pile, C is the southern plumb pile and D is the southern-most batter pile. Bents are numbered 1 through 26. See the plan in Appendix C for additional detail.

2. MAGNOLIA PIER

The overall observed condition of the timber pier piles ranged from **Fair** to **Good**, with limited areas of **Poor** to **Serious** condition observed on the timber batter piles. Minor to moderate damage due to marine borer action was observed on approximately 40 percent of piles (See Photographs 11-15 and Table 1 below). Minor to severe corrosion was observed on the majority of hardware connections within the tidal zone with total corrosion loss on the bolt and nut at one location (see Photographs 16 and 21). Minor to moderate deterioration was observed on the majority of lower cross bracing members in addition to isolated cases of disconnected or broken members (See Photographs 17-20). Approximately 2 piles had significant rot and/or significant section loss at the top of the pile (See Photographs 22-23).

Table 1 below indicates the observed conditions of the timber piles.

TABLE 1
Timber Pier Support Piles

Designation Number	Observed Condition
B26C	Deterioration/delamination of pile 2 ft. above mudline.~ 5% section loss within 5 ft. of tidal zone. Deteriorated

	marine borer hole, 1-2 inch diameter.
B26A	4 ft. of deterioration and delamination of timber below high water.
B25B	3 ft. area of deterioration/delamination between bracing.
B25C	Minor to moderate marine borer activity and minor section loss within the tidal zone.
B24B	Minor to moderate marine borer action, approximately 5 holes around lower bracing connection.
B23D	Marine borer/trenching of batter piles to 8 ft. below high water.
B22C	Deterioration/delamination 4 ft. from high water.
B21C	5 ft. section of deterioration and delamination from high water down
B20A	3 inch diameter marine borer activity and moderate to major rot in pile. ~80-90% section loss at top of pile.
B20B	Minor to moderate marine borer activity at bolt holes. 3-4 ft. deterioration/delamination from high water.
B20D	Minor marine borer deterioration/delamination
B18B	Moderate marine borer/trenching of plumb pile ~6-7' in length.
B17A	Minor marine borer/trenching in pile.
B15	Minor marine borer activity within tidal zone.
B12B	Cracking and trenching in pile. Longitudinal bracing not attached.
B11A	4 ft. section of deterioration/delamination within tidal zone. Minor marine borer activity.
B11D	4 ft. section of deterioration/delamination.
B8D	Minor delamination of pile 5 ft. above mudline.
B8A	Moderate to major rot in batter pile, hollow at top. ~60-70% of cross-section.
B8B	3"x2"x2"deep marine borer activity ~ 2' above mudline.

B5A	Minor delamination in pile ~3' from riprap.

* All other piles visually observed to be in Satisfactory to Good condition.

Although no utilities/building structures, framing, floats, gangways or any other ancillary structures associated with the pier were included in the inspection scope of work, we did note the observed condition of accessible timber members including decking, stringers, split pile caps, cross-bracing and railing members. The timber pile caps were observed to have minor splits and checks (See Photographs 7-8). Several decking members have been replaced however, many deck planks were observed to be deteriorated and split (See Photographs 24-26). Several railing sections were observed to have bene replaced recently, however the remaining railing sections were observed to have minor to moderate checks and splits in addition to loose connections (See Photographs 27-28). It should also be noted that a 10-foot span on the north side and end of the pier are without railing (See Photograph 27).

C. SUMMARY AND RECOMMENDATIONS

1. SUMMARY OF CONDITIONS

The condition of the Magnolia Pier timber piles was observed to be in overall **Fair** to **Good** condition. The tops of the batter piles were observed to be in **Poor** to **Serious** condition. Minor to moderate marine borer damage, delamination and trenching was observed on the pier supporting piles.

The conditions were based on visual observations during the time of inspection. It is unknown as to the subsurface conditions at the site or any information associated with installation of the piles, including embedment depths. GZA did not perform calculations to determine load capacity of the piles or other timber framing members.

The information contained within this report is based on the conditions observed at the time of inspection. The report is for general condition assessment purposes only and is not sufficient, in and of itself, to prepare construction documents for rehabilitation/repair work. Existing conditions are subject to change.

2. RECOMMENDATIONS

The timber pier piles are providing support for the timber deck/walkway above. The age of the piles is unknown, however as the piles were observed to be creosote-treated, they are probably at least 30 years old.

The longevity of timber structures in marine environments is typically in the range of 30 to 50 years. Typically, more exposed elements of a timber structure,

such as members exposed to the direct elements or in the intertidal zone, need replacement or repairs more frequently than the 30 to 50 year duration. Abrasion and impact wear significantly reduces the typical longevity of the piles.

It is reported that the pier exhibits slight movement due to wave and wind acting onto the structure. Based on the pier having a relatively narrow width verses the height, the unknown embedment depths of the piles, the deterioration at the connections and deterioration of the top of the batter piles, we feel that the batter piles and severely deteriorated connections and bracing should be replaced to improve lateral support of the pier. In addition, more frequent batter pile installations along the pier bents should be considered to provide increased lateral support.

Based on the approximate age of the piles and the conditions observed, the timber pier support piles are estimated to have approximately 5 to 10 years of useful life remaining before repairs or replacement should be considered. Due to the deterioration and rot observed on the tops of the timber batter piles and corroded connections, repairs or replacement of these elements should be considered within the next 1 to 3 years, or sooner if conditions worsen. The remaining timber support piles, based on the deterioration observed from marine borers should be considered to be repaired or replaced within 5 to 10 years, or sooner if conditions worsen.

Additionally, based on conditions observed and limited measurements taken, we are concerned about the structural capacity of several members including pile caps, timber stringers, deteriorated timber decking and railing system, including posts and rails. Some of our concerns include, but are not limited to the following:

- The railing does not appear to meet building code requirements with relation to height and spacing. Further investigation would be needed to analyze the structural capacity of the rail system itself with regard to uniform and concentrated loading criteria. In addition, the pier has open sections of the railing at the pier end and along the north side of the pier which should be closed to prevent an accidental fall.
- Timber stringer capacity should be checked, based on loading conditions for the pier.
- Decking members observed to be deteriorated should be replaced.
- Fasteners observed to be corroded or deteriorated should be replaced.
- Re-fastening of the aluminum gangway/timber pier connection should be performed.
- Timber float, bottom-anchored connections should be checked and adjusted as necessary to minimize significant movement.

The frequency of future pile inspections would be dependent on the future repairs and replacement of the members. If no work is performed, inherent to the age of the piles, conditions observed and the marine environment exposure at the site, the piles should be inspected every two years or after major storm, ice or flooding events. Future inspections should concentrate on level of advanced deterioration due to marine borer action, condition of fasteners, and possible impact/vessel-related damage and overall general conditions of the piles.

APPENDIX A

VISUAL INSPECTION LIMITATIONS

1. The observations described in this report were made under the conditions stated herein. The conclusions presented in the report were based solely on the services described therein, and not on scientific tasks or procedures beyond the scope of described services or the time and budgetary constraints.

2. In reviewing this Report, it should be realized that the reported condition of the waterfront structures is based on observations of field conditions during the course of this study along with data made available to GZA GeoEnvironmental, Inc. (GZA). The observations of conditions reflect only the situation present at the specific moment in time the observations were made, under the specific conditions present. It may be necessary to reevaluate the recommendations of this report when subsequent phases of evaluation or repair and improvement provide more data.

3. This report has been prepared for the exclusive use of the City of Gloucester for specific evaluation purposed in accordance with generally accepted inspection practices. No other warranty, expressed or implied, is made.

4. This inspection report has been prepared for this project by GZA. This report is for the City of Gloucester's evaluation and management purposes only and is not sufficient, in and of itself, to prepare construction documents or an accurate bid.

GZA GeoEnvironmental, Inc.

PHOTOGRAPHIC LOG

Client Name:	Site Location:	Project No.
City of Gloucester Harbormaster	Magnolia Pier	18.0172459.00

Photo No.	Date:
1	2015

Direction Photo Taken:

Aerial

Description:

Aerial view of Magnolia Pier.

Photo No.	Date:
2	08/06/15

Direction Photo Taken:

Westerly

Description:

Topside view of Magnolia Pier.

GZA GeoEnvironmental, Inc.		PHOTOGRAPHIC LOG
Client Name: City of Gloucester Harbormaster	**Site Location:** Magnolia Pier	**Project No.** 18.0172459.00

Photo No. 3	**Date:** 08/06/15

Direction Photo Taken:

Westerly

Description:

View of Magnolia Pier along outer, south side.

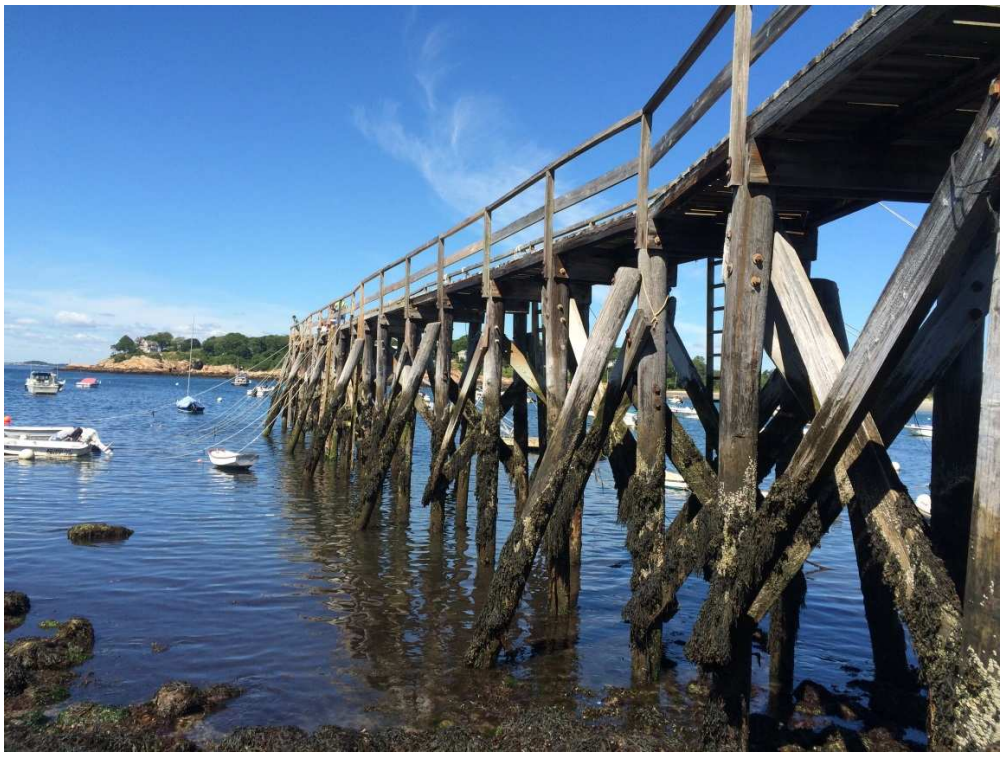


Photo No. 4	**Date:** 08/06/15

Direction Photo Taken:

Easterly

Description:

View of Magnolia Pier, along north side. Note: Ladders on either side of pier provide access to dinghies.

Client Name:	Site Location:	Project No.
City of Gloucester Harbormaster	Magnolia Pier	18.0172459.00

Photo No.	Date:
5	08/06/15

Direction Photo Taken:

Westerly

Description:

Underside of Magnolia Pier. Note: Timber cross bracing, timber piles and timber framing members.

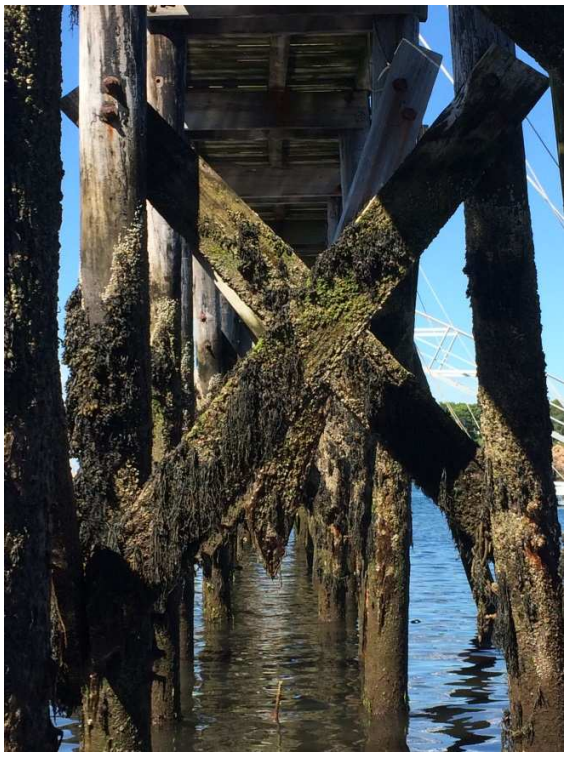


Photo No.	Date:
6	08/06/15

Direction Photo Taken:

Northerly

Description:

Aluminum gangway leading to seasonal bottom-anchored timber float. Note: Observed orientation of float different on 08/21/15.

GZA GeoEnvironmental, Inc. **PHOTOGRAPHIC LOG**

Client Name:	Site Location:	Project No.
City of Gloucester Harbormaster	Magnolia Pier	18.0172459.00

Photo No.	Date:
7	08/06/15

Direction Photo Taken:

Northerly

Description:

Typical pier framing. Note: Split pile caps and rail post notched into timber pile.

Photo No.	Date:
8	08/06/15

Direction Photo Taken:

Easterly

Description:

Typical pier framing. Note: 6x6 timber stringers spaced at ±2.5'-3' o.c. with apparent creosote treatment and corroded fasteners.

GZA GeoEnvironmental, Inc. **PHOTOGRAPHIC LOG**

Client Name:	Site Location:	Project No.
City of Gloucester Harbormaster	Magnolia Pier	18.0172459.00

Photo No.	Date:
9	08/21/15

Direction Photo Taken:
Easterly

Description:

Aluminum gangway connection.

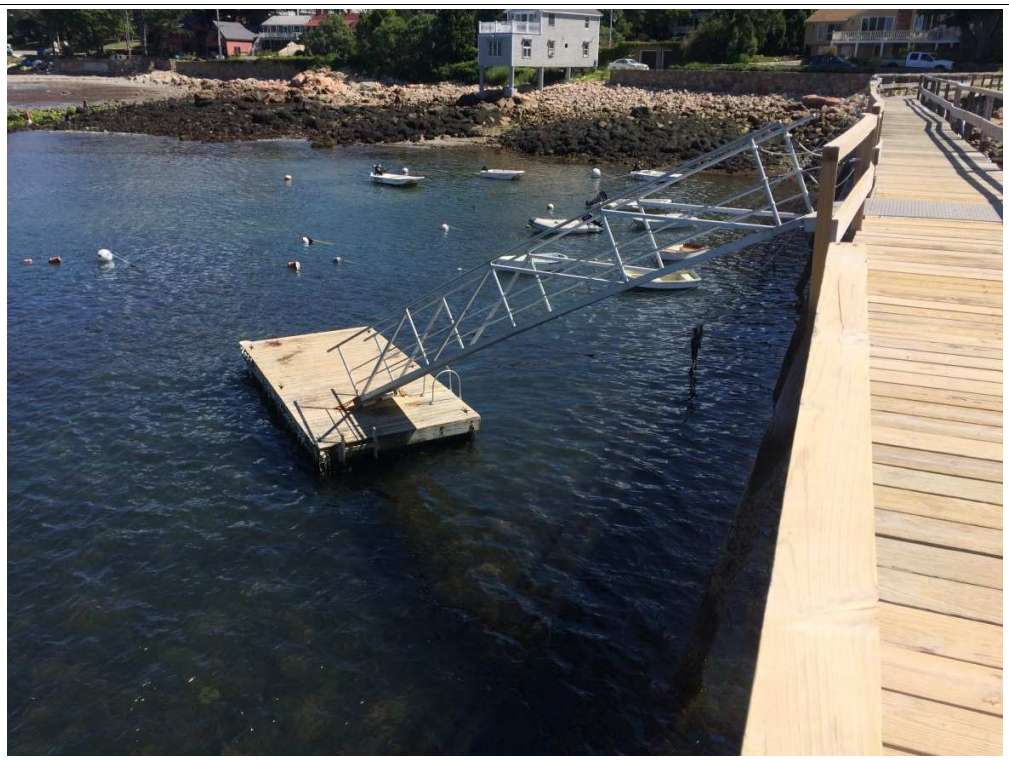
Photo No.	Date:
10	08/06/15

Direction Photo Taken:

Easterly

Description:

Seasonal bottom-anchored timber float and aluminum gangway.



GZA GeoEnvironmental, Inc.		PHOTOGRAPHIC LOG
Client Name: City of Gloucester Harbormaster	**Site Location:** Magnolia Pier	**Project No.** 18.0172459.00

Photo No. 11	**Date:** 08/21/15

Direction Photo Taken:

-

Description:

Typical minor to moderate marine borer damage on timber piles.

Photo No. 12	**Date:** 08/21/15

Direction Photo Taken:

-

Description:

Typical minor to moderate marine borer damage on timber piles.

GZA GeoEnvironmental, Inc.		PHOTOGRAPHIC LOG
Client Name: City of Gloucester Harbormaster	**Site Location:** Magnolia Pier	**Project No.** 18.0172459.00

Photo No. 13	**Date:** 08/21/15

Direction Photo Taken:

-

Description:

Moderate to severe deterioration/delamination of timber pile within tidal zone.

Photo No. 14	**Date:** 08/21/15

Direction Photo Taken:

-

Description:

Minor to moderate delamination/trenching of timber pile.

Client Name:	Site Location:	Project No.
City of Gloucester Harbormaster	Magnolia Pier	18.0172459.00

Photo No.	Date:
15	08/21/15

Direction Photo Taken:

-

Description:

Minor to moderate deterioration/delamination of timber pile within tidal zone.

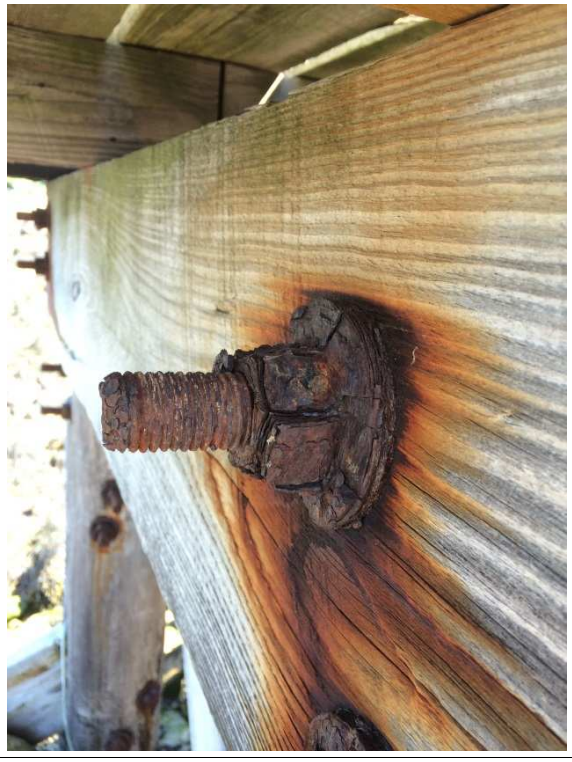
Photo No.	Date:
16	08/06/15

Direction Photo Taken:

-

Description:

Typical corrosion of steel fasteners.



Client Name:	Site Location:	Project No.
City of Gloucester Harbormaster	Magnolia Pier	18.0172459.00

Photo No.	Date:
17	08/21/15

Direction Photo Taken:

-

Description:

Typical corrosion of steel fasteners within tidal zone.

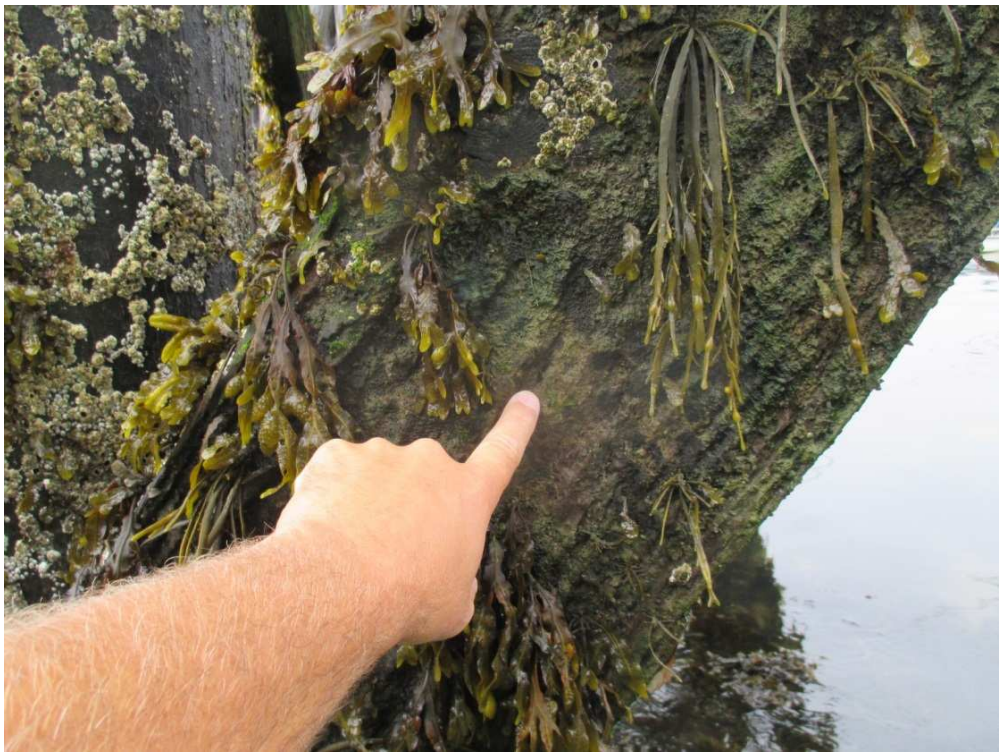
Photo No.	Date:
18	08/21/15

Direction Photo Taken:

-

Description:

Typical minor to moderate deterioration of lower cross bracing members.



Client Name:	Site Location:	Project No.
City of Gloucester Harbormaster	Magnolia Pier	18.0172459.00

Photo No.	Date:
19	08/21/15

Direction Photo Taken:

-

Description:

Typical minor to moderate deterioration of lower cross bracing members.

Photo No.	Date:
20	08/21/15

Direction Photo Taken:

-

Description:

Disconnected cross bracing member at Bent 15.

Client Name:	Site Location:	Project No.
City of Gloucester Harbormaster	Magnolia Pier	18.0172459.00

Photo No.	Date:
21	08/06/15

Direction Photo Taken:

-

Description:

Deteriorated fastener.

Photo No.	Date:
22	08/21/15

Direction Photo Taken:

-

Description:

Moderate to major deterioration in top of batter pile. Approximately 60% loss of section.

Client Name:	Site Location:	Project No.
City of Gloucester Harbormaster	Magnolia Pier	18.0172459.00

Photo No.	Date:
23	08/21/15

Direction Photo Taken:

-

Description:

Moderate to major deterioration in top of batter pile. Approximately 80 to 90% loss of section.

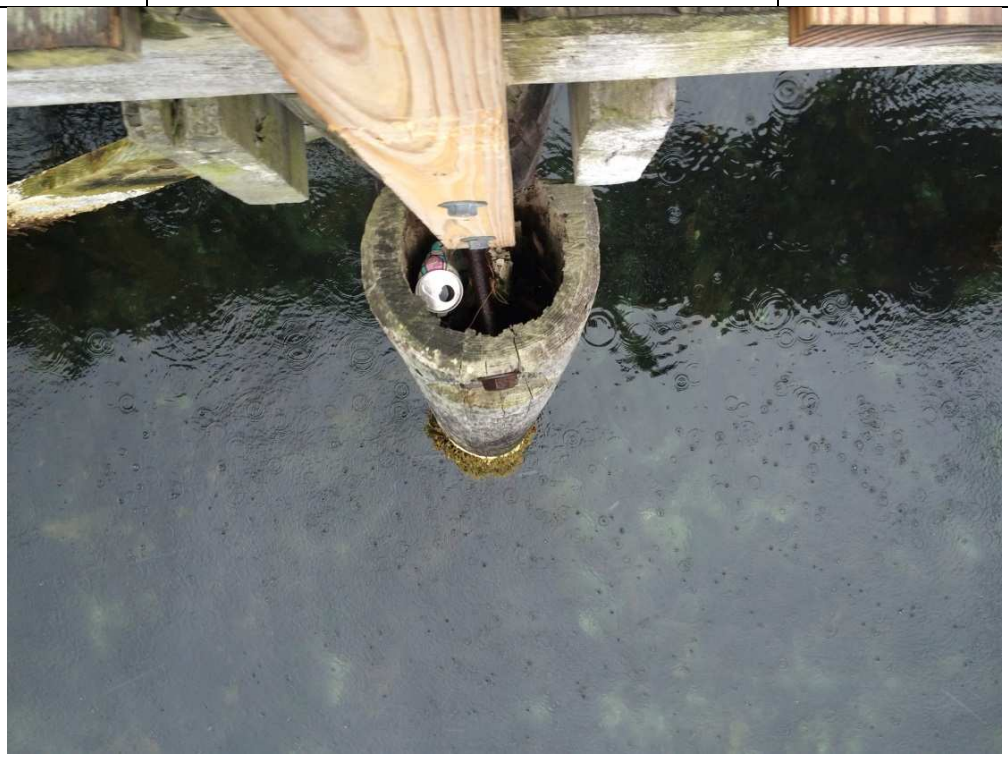


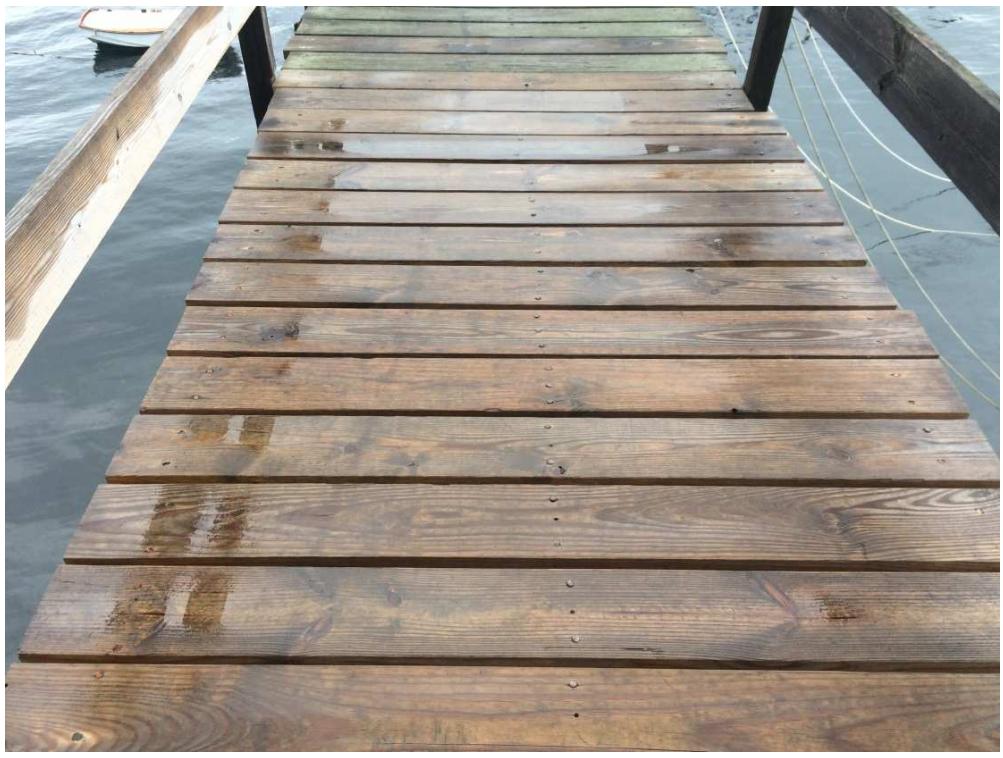
Photo No.	Date:
24	08/21/15

Direction Photo Taken:

Westerly

Description:

Typical condition of newer decking members.



Client Name:	Site Location:	Project No.
City of Gloucester Harbormaster	Magnolia Pier	18.0172459.00

Photo No.	Date:
25	08/21/15

Direction Photo Taken:

Westerly

Description:

Typical condition of older decking members. Note: Moderate checking and splitting.

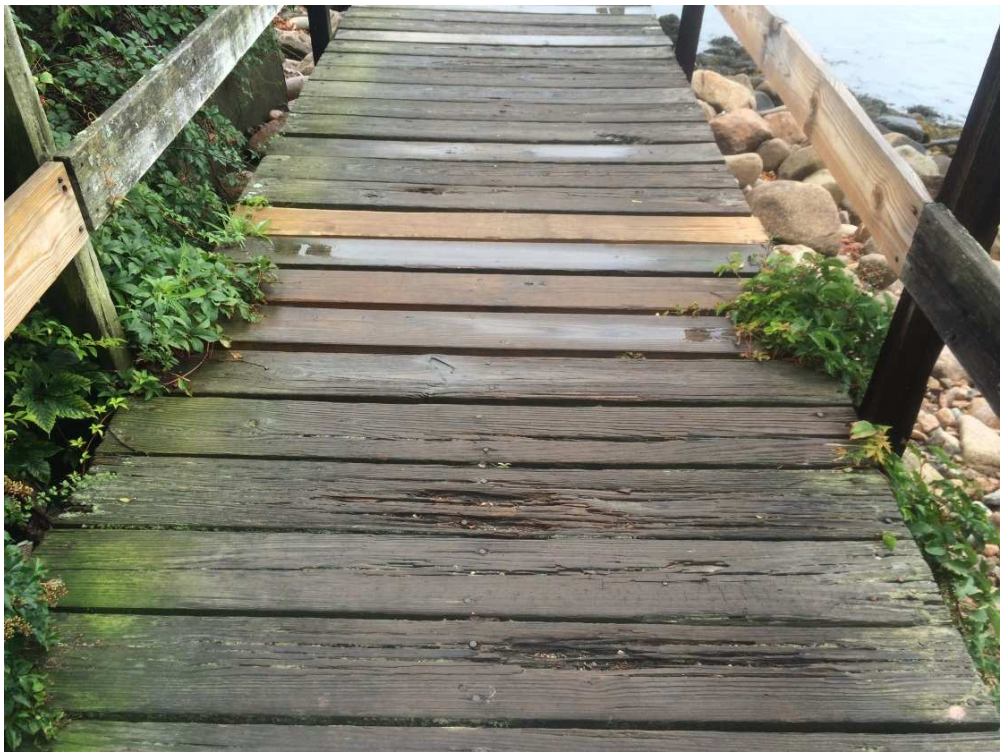


Photo No.	Date:
26	08/21/15

Direction Photo Taken:

-

Description:

Typical condition of older deck member. Note: Moderate to severe check.

GZA GeoEnvironmental, Inc. **PHOTOGRAPHIC LOG**

Client Name:	Site Location:	Project No.
City of Gloucester Harbormaster	Magnolia Pier	18.0172459.00

Photo No.	Date:
27	08/21/15

Direction Photo Taken:

Westerly

Description:

Typical condition of newer timber railing members. No railing on pier end.

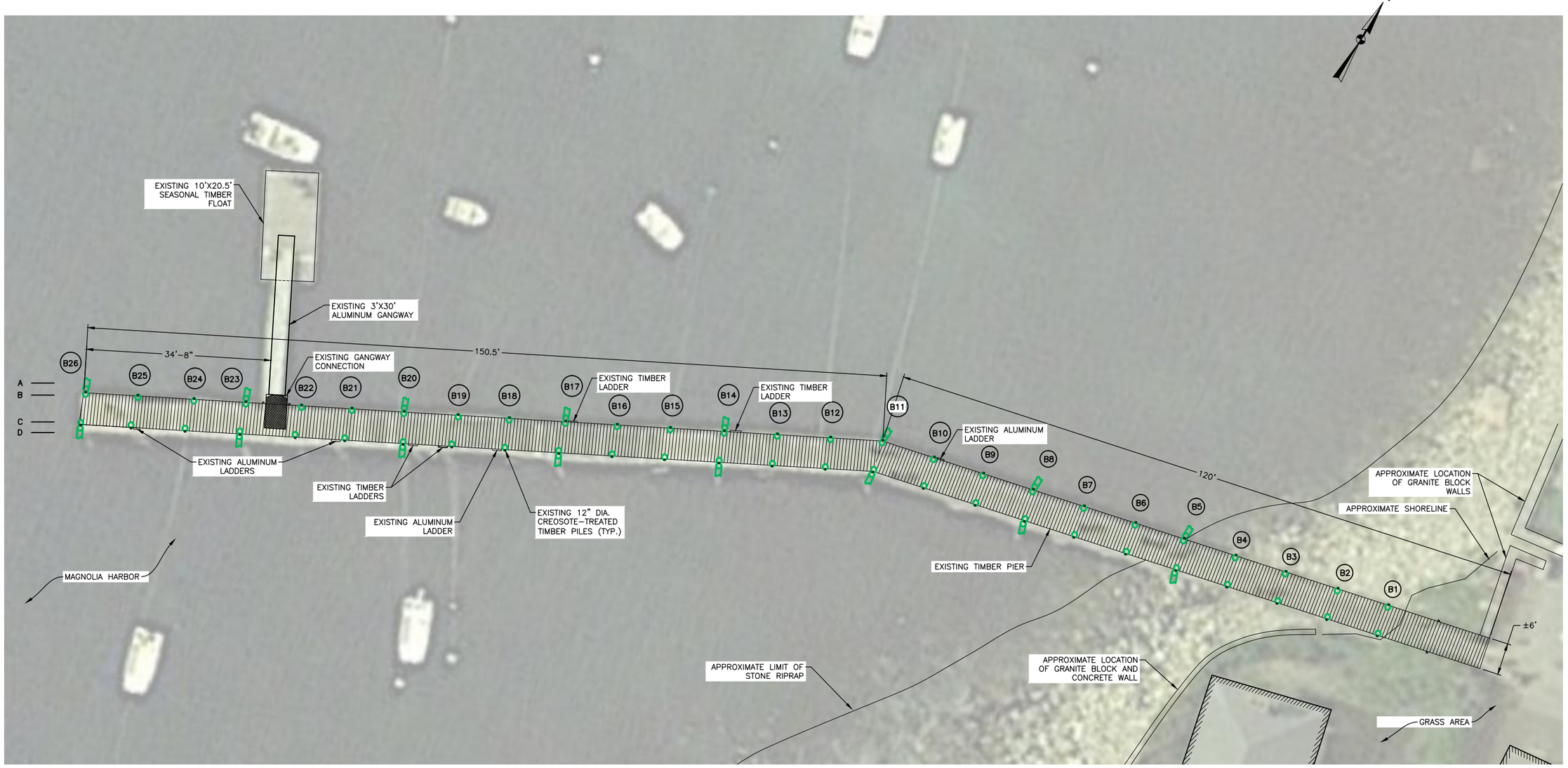
Photo No.	Date:
28	08/21/15

Direction Photo Taken:

Easterly

Description:

Transition from newer railing to older railing members.



EXISTING SITE PLAN
SCALE: 1"=10'

LEGEND:

- (B2) BENT DESIGNATION NO.
- O EXISTING TIMBER PILE
- A —— PIER PILE ROW DESIGNATION

0 5 10 20
SCALE IN FEET

NOTES:

1. INSPECTION PERFORMED BY GZA GEOENVIRONMENTAL, INC. ON AUGUST 21, 2015 AND REPRESENTS CONDITIONS AT THE TIME OF THE INSPECTION.
2. PILE LOCATIONS ARE APPROXIMATE AND ARE FOR INSPECTION REFERENCE ONLY.
3. SITE PLAN CREATED BY TAKING FIELD MEASUREMENTS AND USING AN AERIAL IMAGE TO ORIENT LOCATION.
4. BENT B1 IS LOCATED APPROXIMATELY 20' FROM THE LANDSIDE BLOCK WALLS, NO INTERMEDIATE PILE BENT WAS OBSERVED WITHIN THIS AREA.

NO.	ISSUE/DESCRIPTION	BY	DATE

MAGNOLIA PIER
54 SHORE ROAD
GLOUCESTER, MA

APPENDIX C
EXISTING SITE INSPECTION PLAN

PREPARED BY:
GZA GeoEnvironmental, Inc.
Engineers and Scientists
www.gza.com

PREPARED FOR:
CITY OF GLOUCESTER HARBORMASTER AND WATERWAYS BOARD
19 HARBOR LOOP
GLOUCESTER, MA 01930

PROJ MGR:	DAS	REVIEWED BY:	ABB	CHECKED BY:	
DESIGNED BY:	DAS	DRAWN BY:	RKT	SCALE:	AS NOTED
DATE:	SEPTEMBER 2015	PROJECT NO.	18.0172459.00	REVISION NO.	

FIGURE 1
SHEET NO. 1 OF 1